Arctic Clouds

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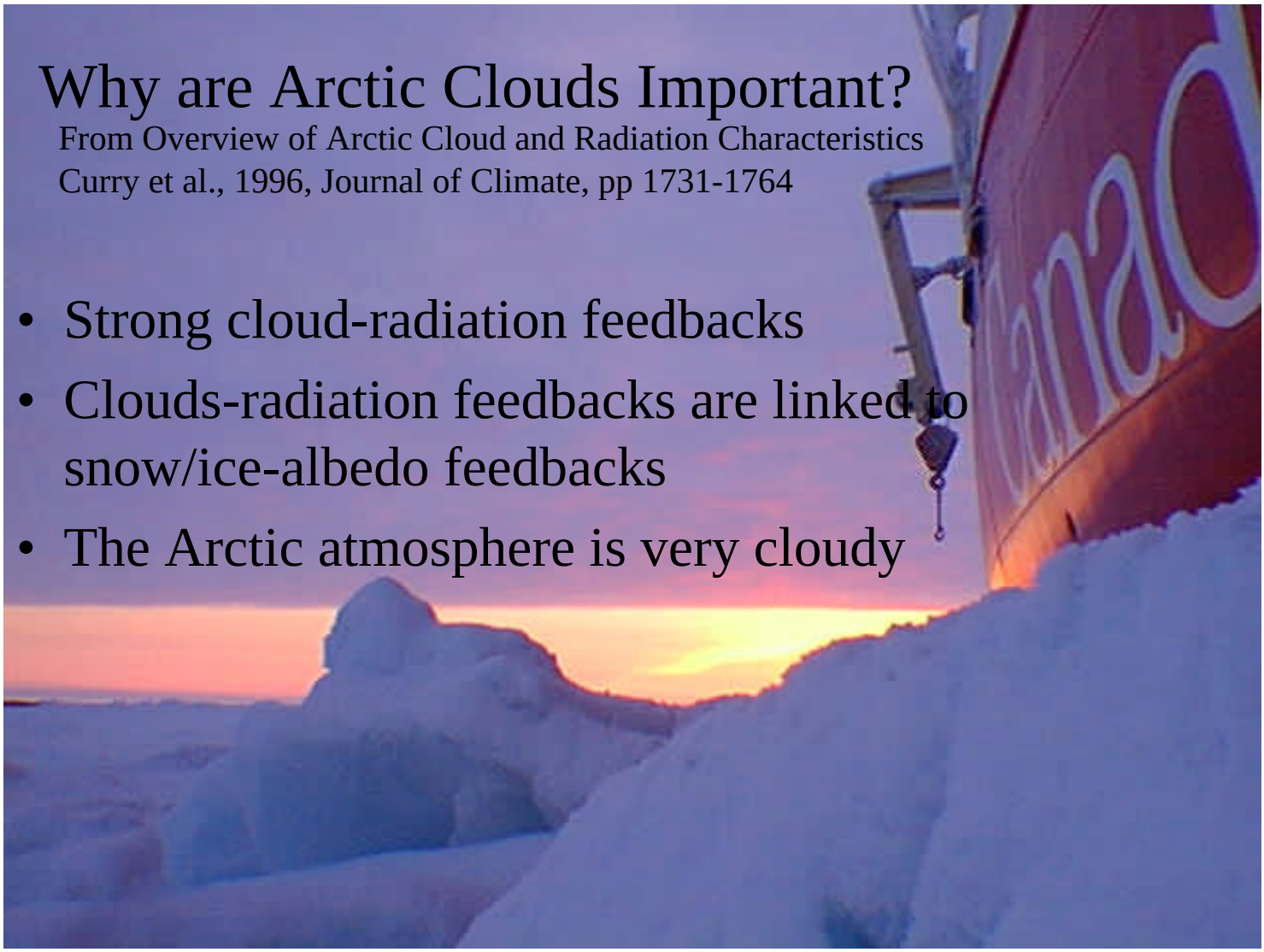
Why is the Arctic important?

From “Status of and Outlook for Large Scale Modeling of Atmosphere-Ice-Ocean Interactions in the Arctic” – Randall et al., 1998, BAMS, 197-219

- Coupled climate models show the largest disagreements in the polar regions
- CO_2 warming may be strongly amplified by retreat and thinning of sea ice
- The North Atlantic thermohaline circulation exerts important controls on climate variability on scales ranging from years to millennia



Why are Arctic Clouds Important?

From Overview of Arctic Cloud and Radiation Characteristics
Curry et al., 1996, Journal of Climate, pp 1731-1764

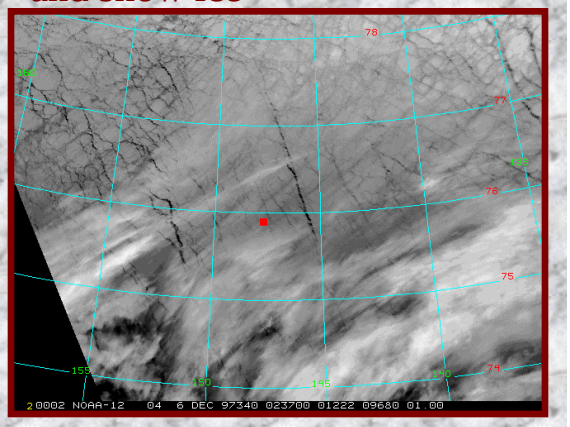
- Strong cloud-radiation feedbacks
- Clouds-radiation feedbacks are linked to snow/ice-albedo feedbacks
- The Arctic atmosphere is very cloudy

Why are Arctic Clouds Hard?

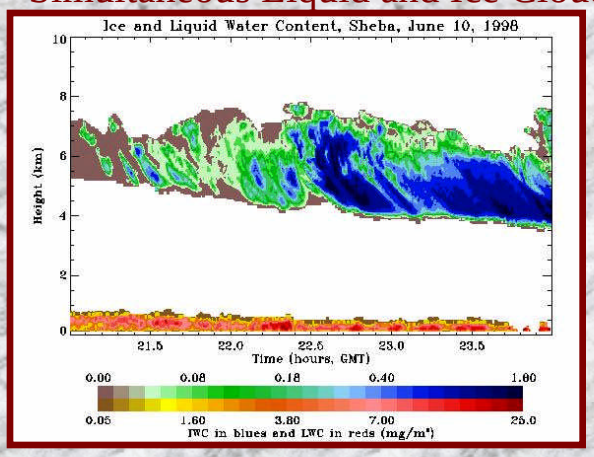
Polar Night

Sparsely Inhabited

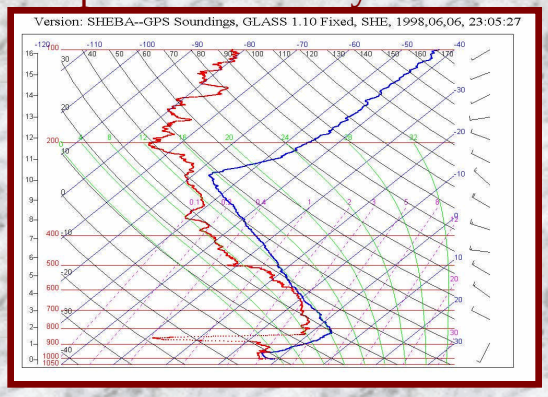
Low contrast between clouds and snow ice



Simultaneous Liquid and Ice Clouds



Temperature/humidity inversions

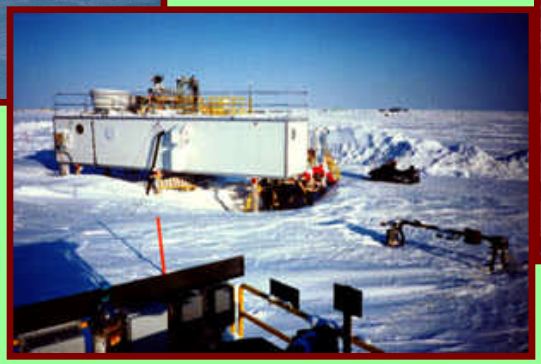


SHEBA

SAFIRE

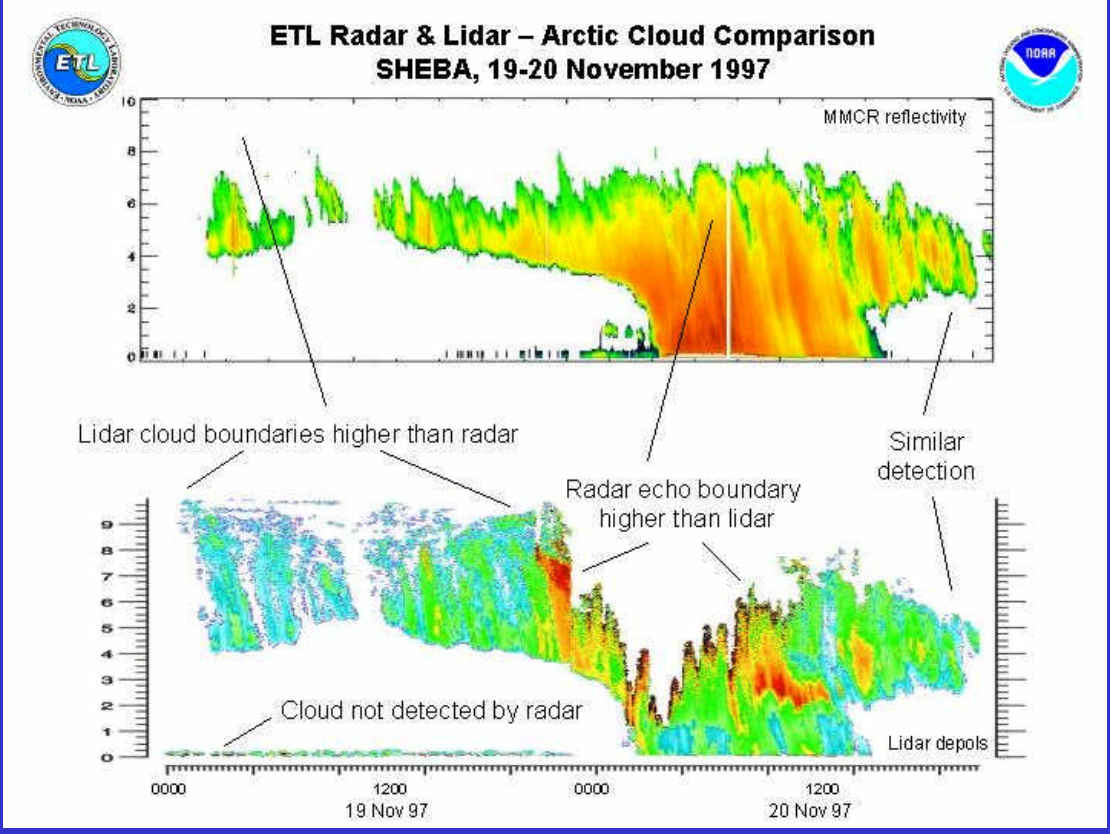
DOE/ARM/NSA

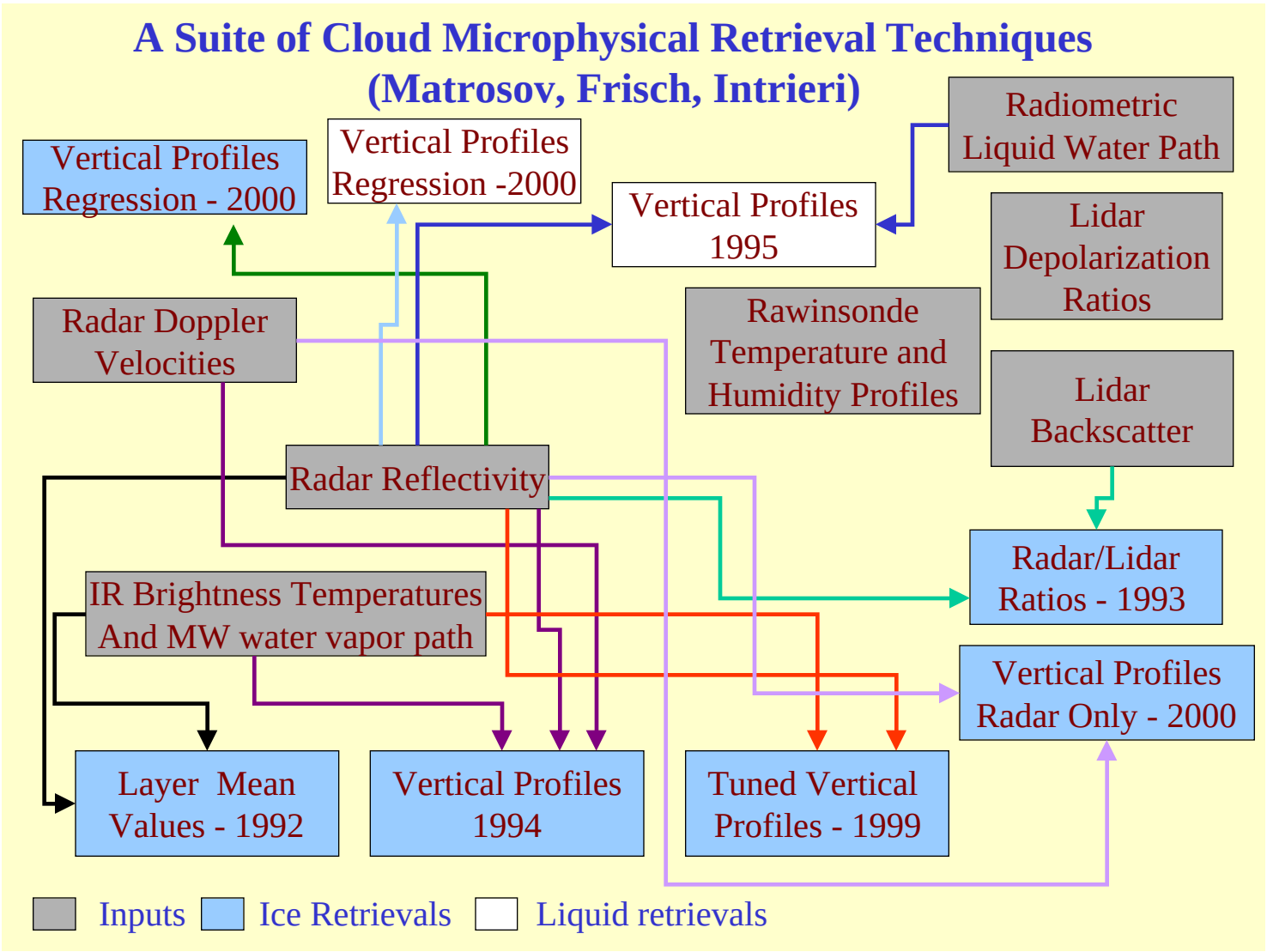
FIRE – ACE



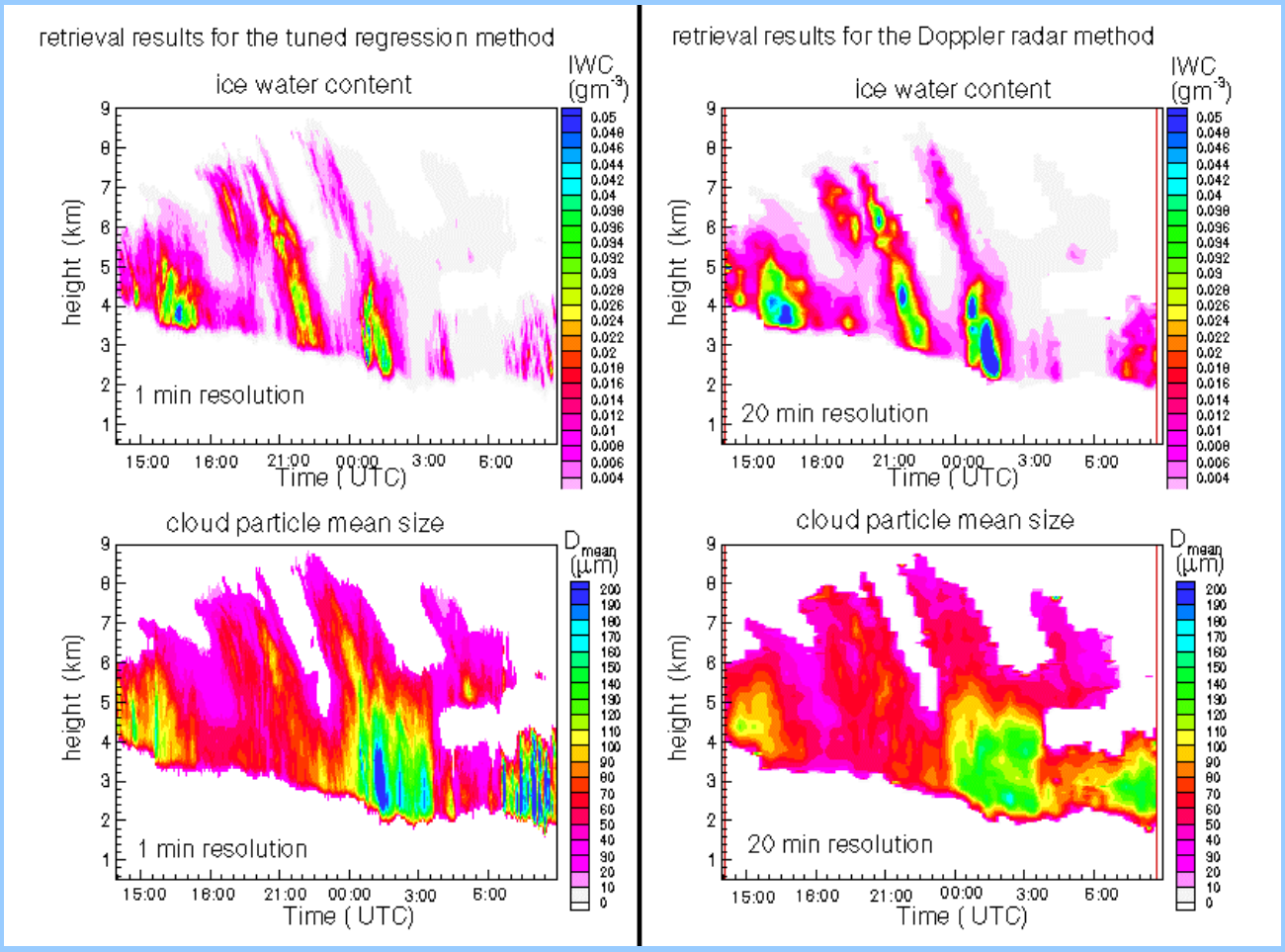
Instruments

Combining Information From Instruments Operating at Different Wave Lengths




A Suite of Cloud Microphysical Retrieval Techniques
(Matrosov, Frisch, Intrieri)
Radiometric Liquid Water Path
Vertical Profiles Regression - 2000
Vertical Profiles Regression -2000
Vertical Profiles 1995
Lidar Depolarization Ratios
Radar Doppler Velocities
Rawinsonde Temperature and Humidity Profiles
Lidar Backscatter
Radar Reflectivity
Radar/Lidar Ratios - 1993
IR Brightness Temperatures And MW water vapor path
Vertical Profiles Radar Only - 2000
Layer Mean Values - 1992
Vertical Profiles 1994
Tuned Vertical Profiles - 1999
Inputs
Ice Retrievals
Liquid retrievals

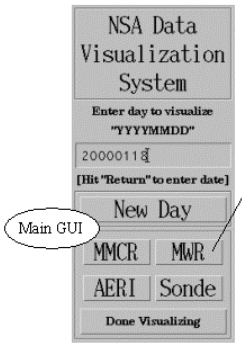
18 hour ice cloud case observed on April 28-29 1998 during SHEBA – Results



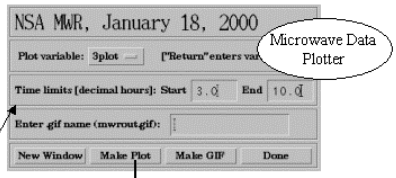
Subjective selection from the suite of techniques to produce daily retrievals

IDL GUI Interfaces

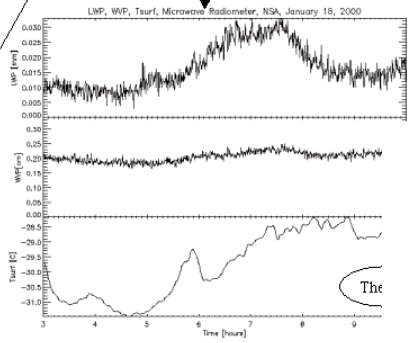
We have developed a GUI in IDL for visualizing data from the ARM-NSA site. This tool helps us determine which type of cloud microphysics retrieval is applicable to the given atmospheric/cloud conditions.



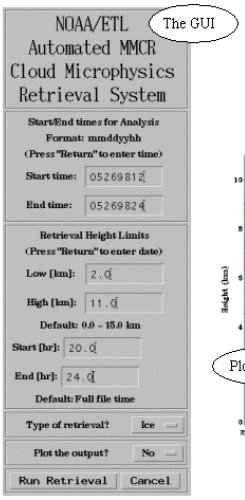
Main GUI



Microwave Data Plotter



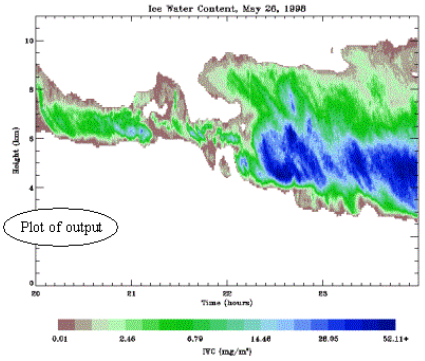
The



The GUI

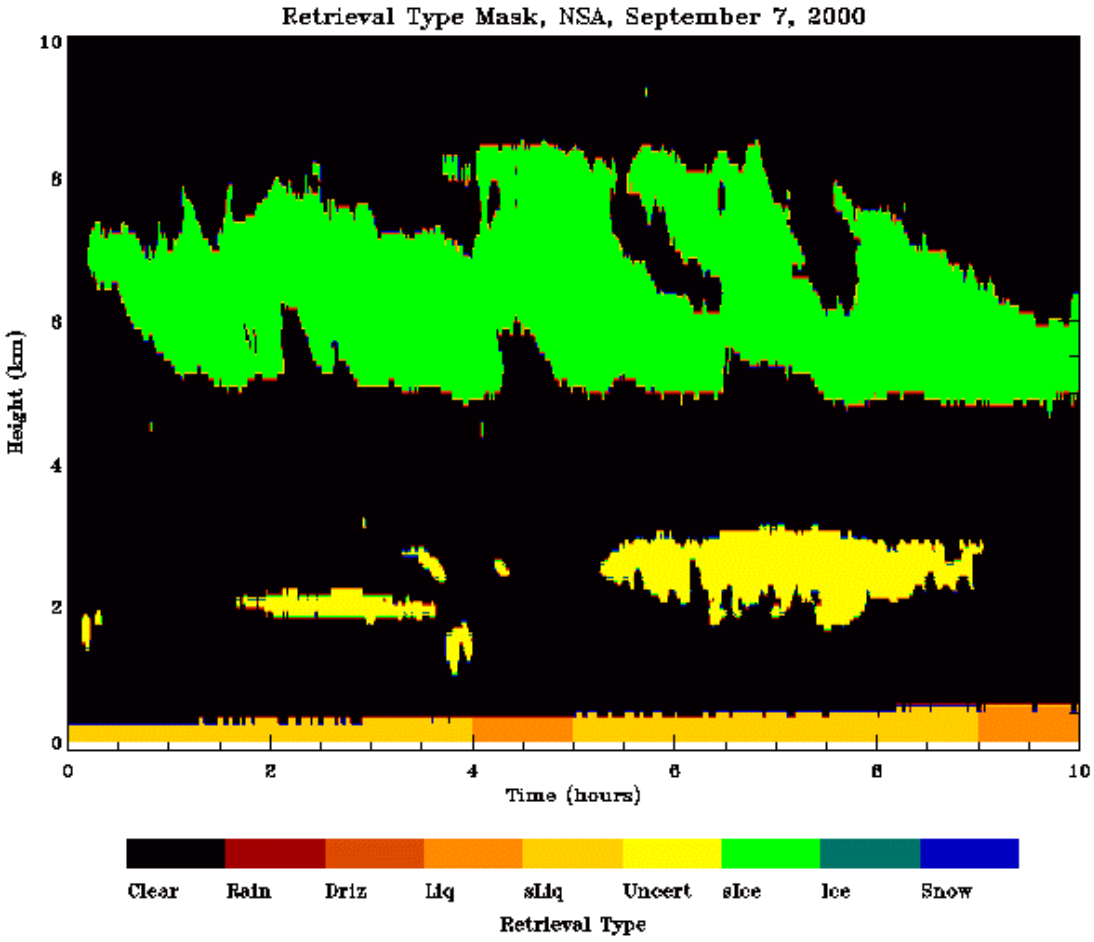
Microphysical Retrievals

We have created an IDL-GUI for running cloud microphysics retrievals using radar and radiometer data.

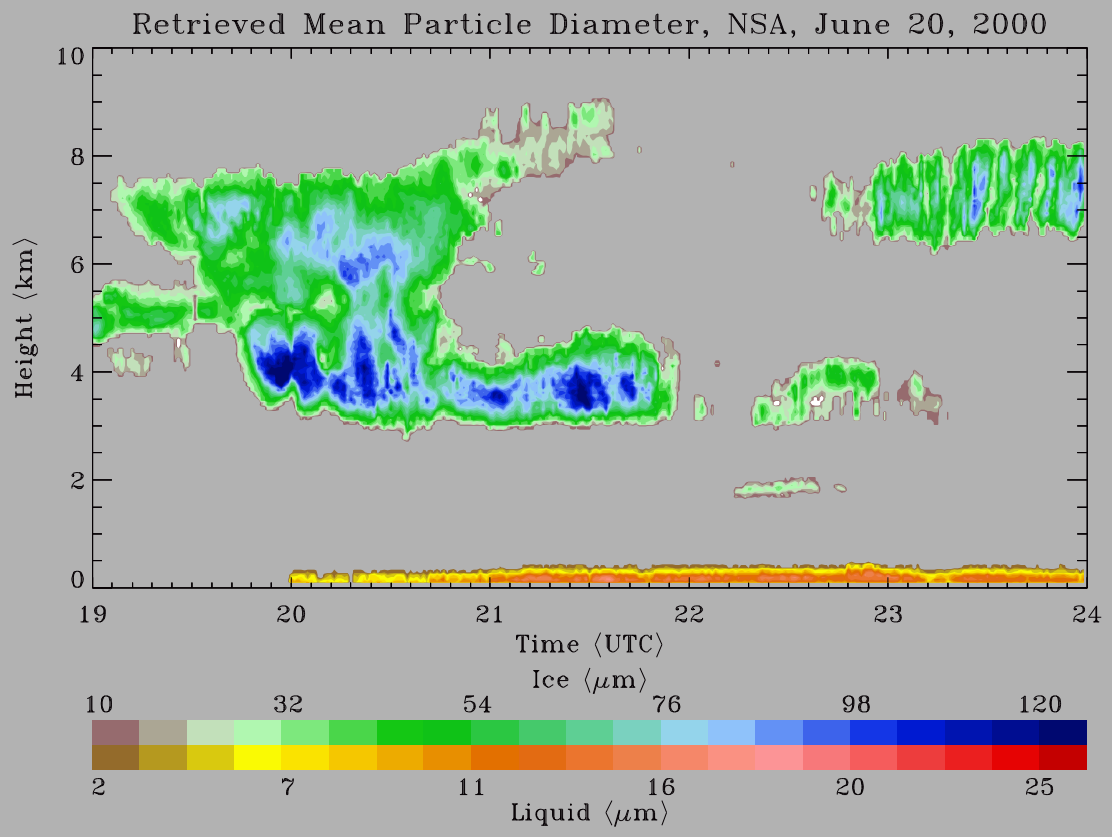


Plot of output

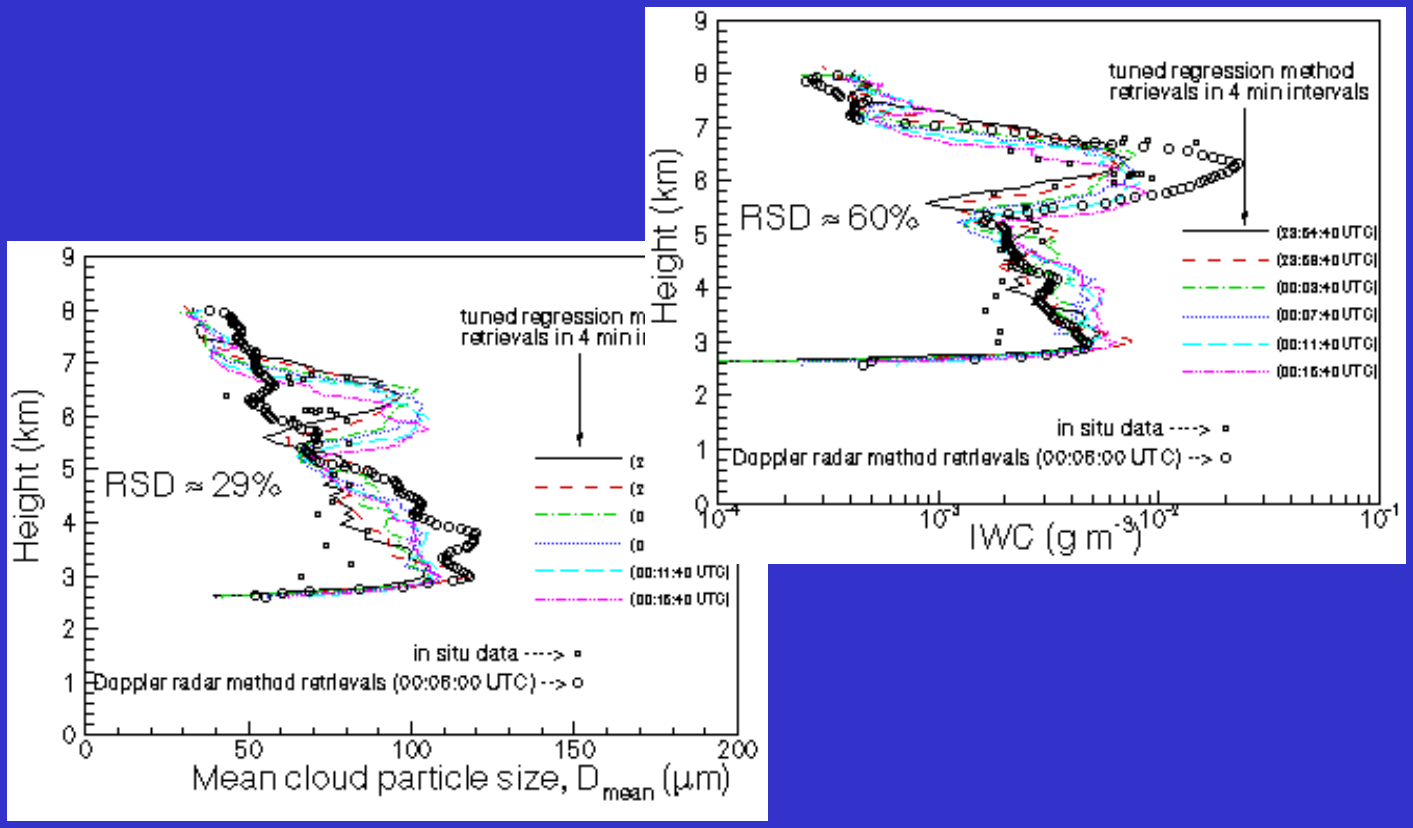
Cloud Classification



Retrievals From Barrow, AK
June 20th, 2000

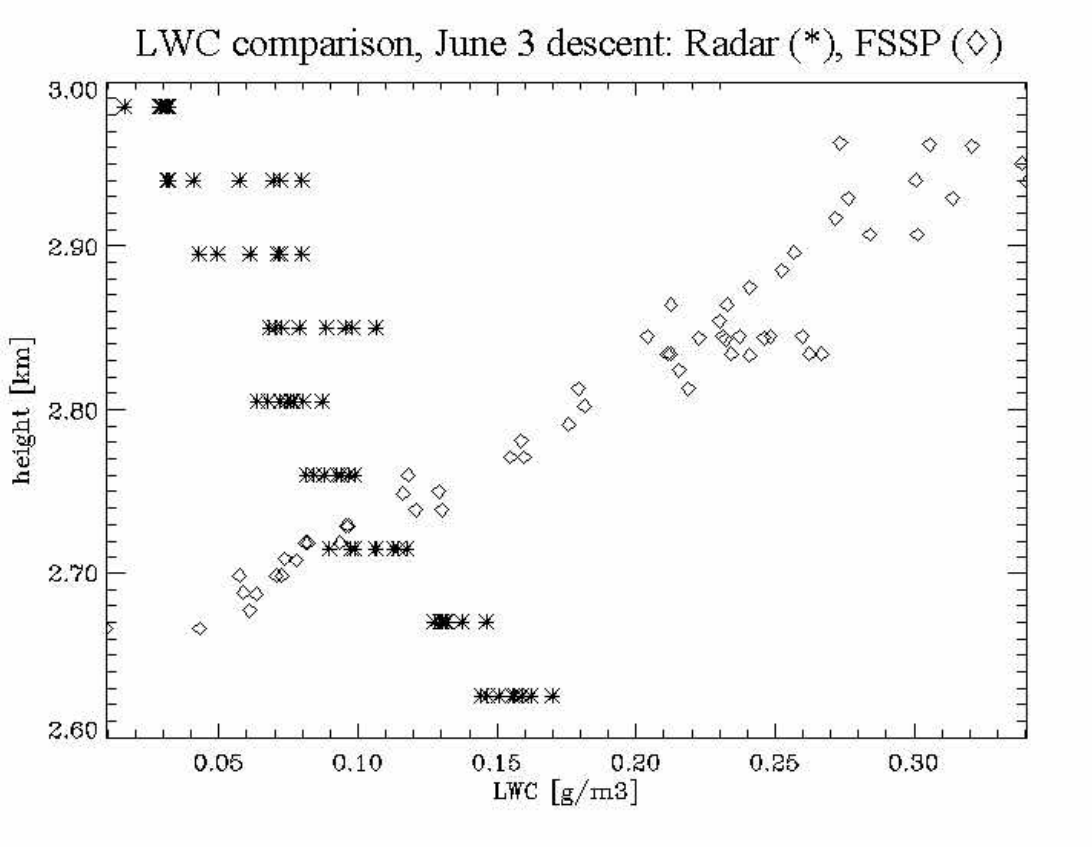


Validation with Aircraft Measurements



36 Flights Over the SHEBA Ice Camp
During April – July, 1998

Problem Identification with Aircraft Measurements



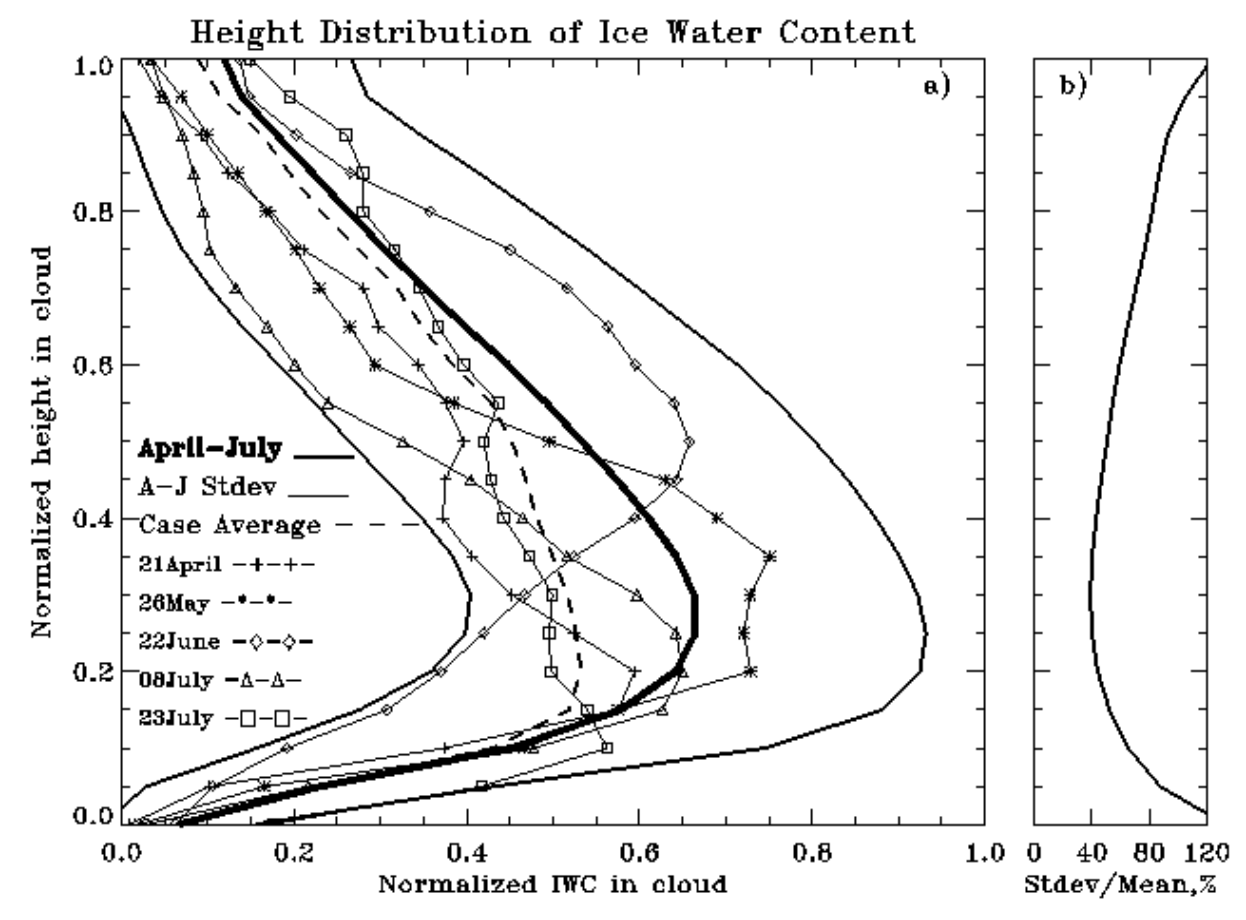
Cloudiness Statistics during April-July 1998 at SHEBA

	Fractional Cloudiness	All-liquid (and single layer)	All-ice (and single layer)
April	93.1	4.2 (0.0)	21.3 (7.0)
May	88.0	23.2 (3.8)	17.6 (6.1)
June	87.8	18.4 (4.5)	23.4 (7.9)
July	93.9	23.2 (5.6)	15.0 (5.9)
All Months	90.7	17.3 (3.5)	19.3 (6.7)

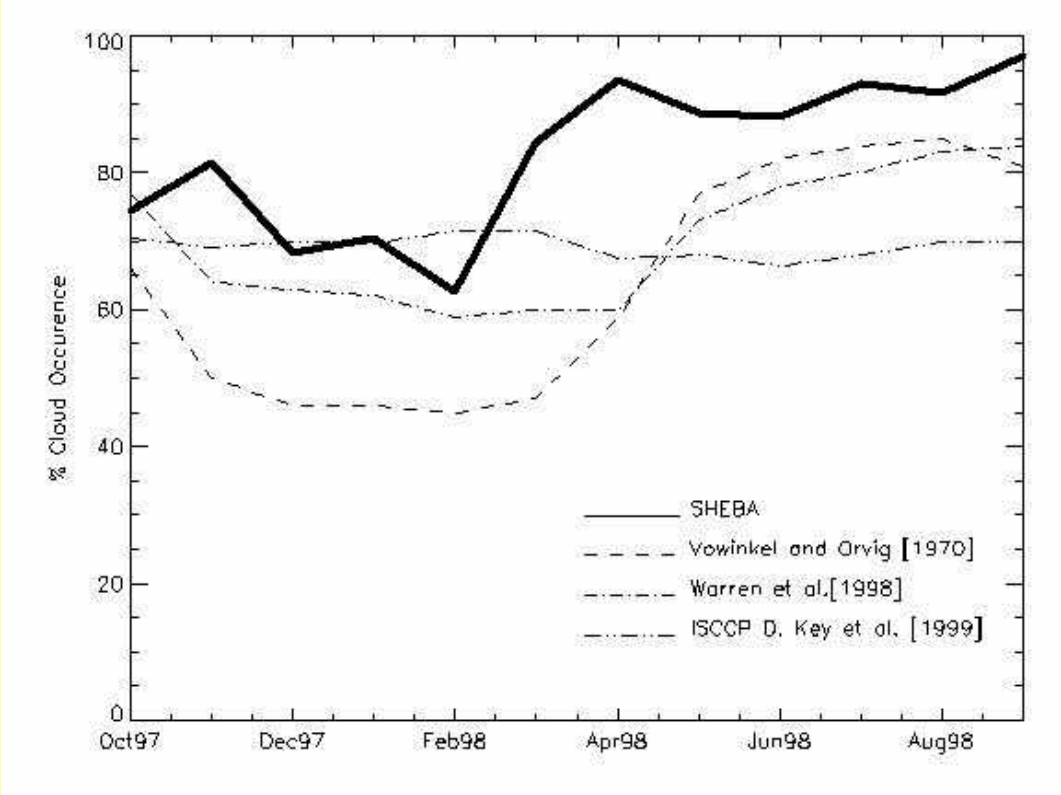
Retrieval Statistics during April-July, 1998 at SHEBA

	Range	**Median**	**Mean**	**Mean (flight days)**
Effective Radius (liquid)	3-20 μm	6.9 μm	7.4 μm	6.2 μm
Liquid Water Content	0-0.7 g/m^3	0.06 g/m^3	0.1 g/m^3	0.08 g/m^3
Mean Diameter (ice)	7-300 μm	46 μm	60 μm	75 μm
Ice Water Content	0-0.1 g/m^3	0.001 g/m^3	0.005 g/m^3	0.007 g/m^3

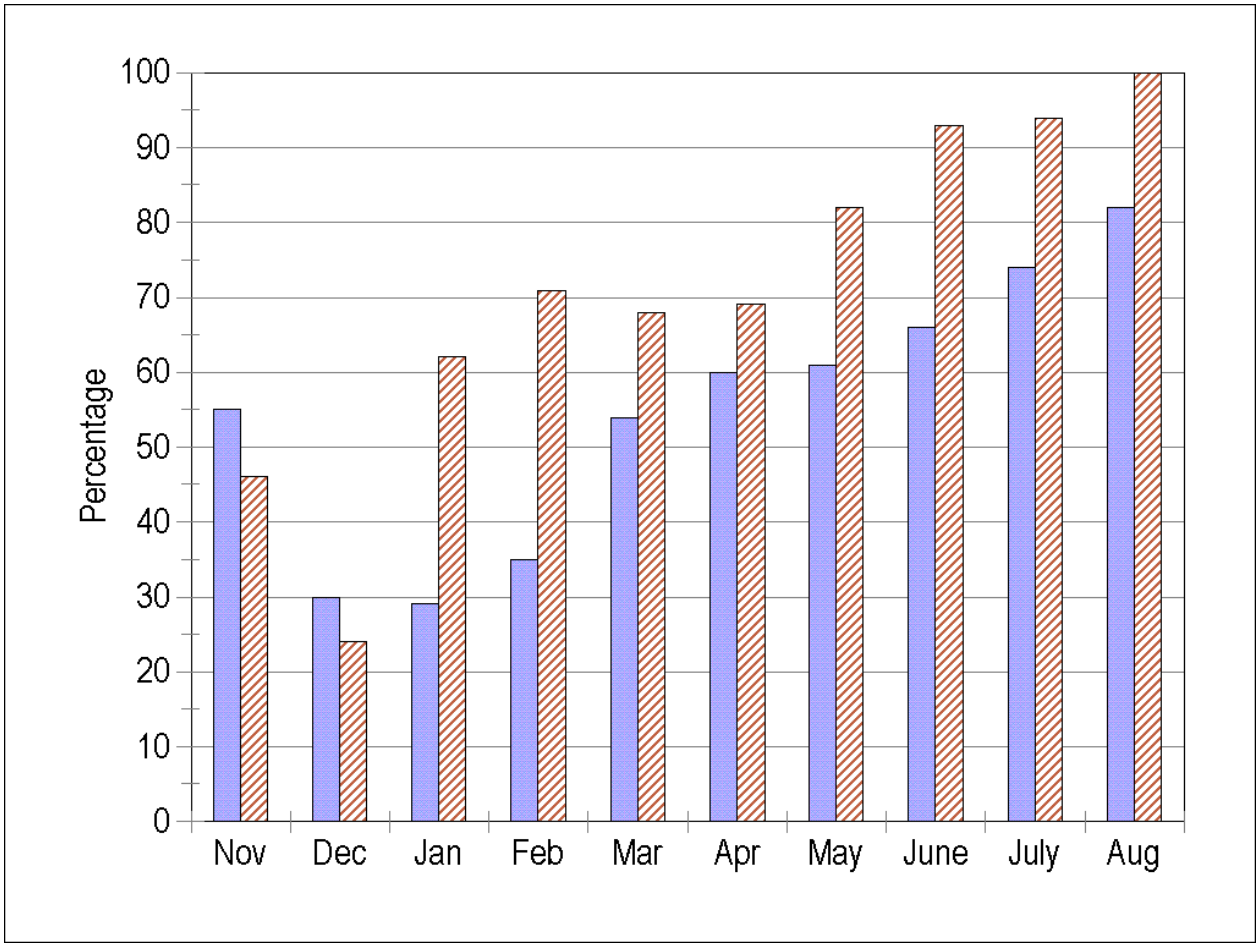
Retrieved Vertical Profiles



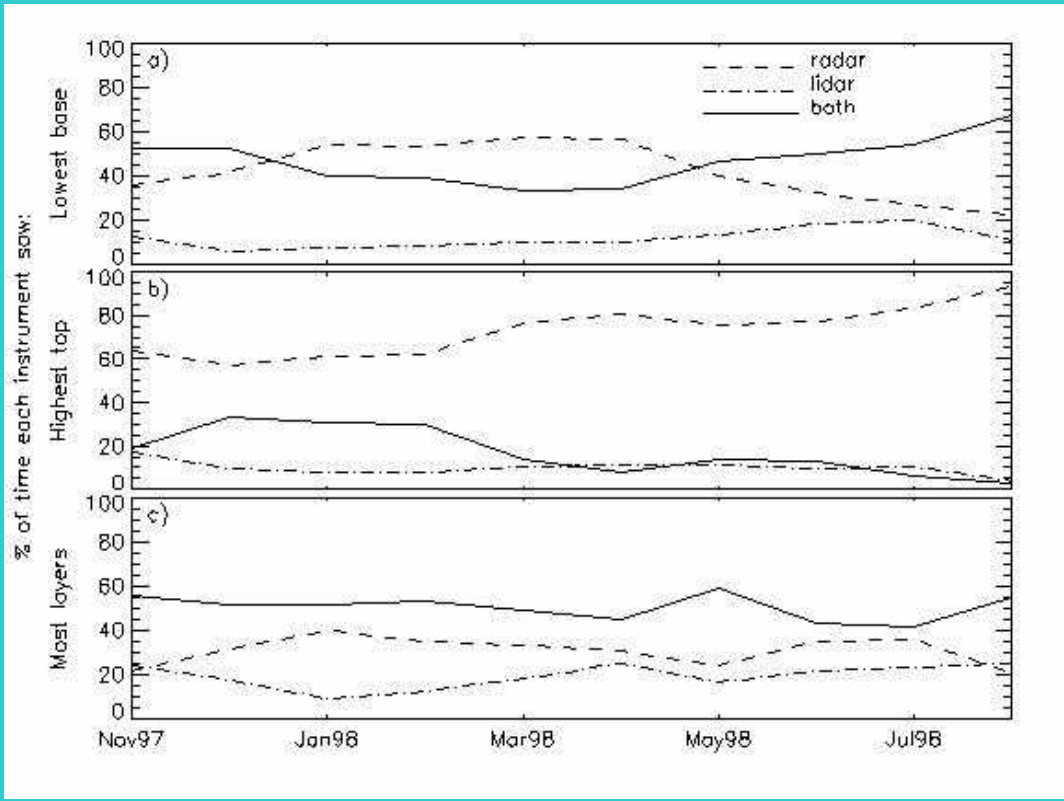
Monthly Fraction of Cloud Occurrence



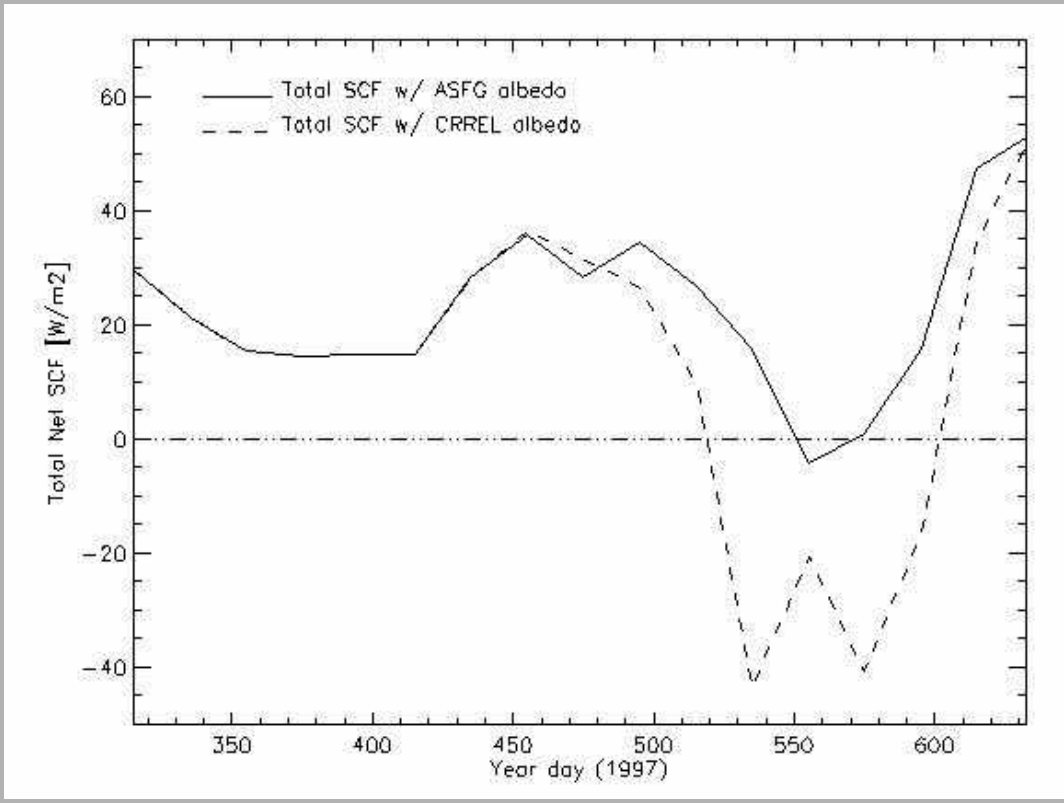
Monthly Fraction of Clouds with Liquid Phase and Fraction of Clouds which attenuate the lidar



Comparison of Echo Boundary Detection with Radar and Lidar



Total Cloud Forcing Over Arctic Ocean



Research in Publication Phase

- An Annual Cycle of Cloud Characteristics Observed by Radar and Lidar at SHEBA (Intrieri, Uttal, Shupe, McCarty)
- Cloud Water Contents and Hydrometeor Sizes During the FIRE-Arctic Clouds Experiment (Shupe, Uttal, Matrosov, Frisch)
- Annual Cycle of Cloud Forcing Observed at SHEBA (Intrieri, Fairall, Shupe and Persson)
- Airborne Studies of Cloud Structures over the Arctic Ocean and Comparison with Retrievals from Ship-Based Remote Sensing Measurements (Hobbs, Rango, Shupe, Uttal)
- Cloud Coverage and Height During FIRE-ACE Derived from AVHRR DATA (Minnis and others)

SEARCH

Study of Environmental Arctic Change

National Oceanic and Atmospheric Administration

National Aeronautics and Space Administration

U.S. Environmental Protection Agency

National Science Foundation

U.S. Department of Defense

U.S. Department of Energy

Cloud Bow Over the SHEBA Ice Camp on July 15th, 1998